CHAPTER 9
WASTEWATER TREATMENT

9-1. General.

Basic design criteria for domestic wastewater treatment systems can be found in TM 5-814-3/AFM 88-11, Volume 3. This chapter provides information and guidance on those aspects unique to cold regions and presents general design criteria for those treatment systems most commonly used in the Arctic and Subarctic.

9-2. Wastewater characteristics.

Wastewater characteristics in the cold regions will generally be different from those in temperate regions, with respect to quantity, quality, and temperature. The total quantity of wastewater discharged at military installations in cold regions tends to be very close to the quantity supplied for potable water use since there is little external or industrial use, storm water is usually excluded, and groundwater infiltration is not a factor in the newer insulated and tightly sealed pipe systems. As a result wastewater in the Arctic and Subarctic tends to be more domestic in nature and higher in strength than at comparable facilities elsewhere.

a. Quantity. The determination of design flows should be based on a special analysis of the installation. The population equivalents and capacity factors presented in TM 5-814-3/AFM 88-11, Vol.3 will tend to overestimate the volume of flow to be expected at remote installations in the Arctic and Subarctic with small populations. This may result in operational problems with some biological treatment units. Selection of less sensitive processes or use of two smaller units in parallel will avoid the problem if the design cannot be based on actual flows.

b. Quality. The mass of pollutants in cold region wastewaters is comparable to that in other locations but the concentration will generally be higher because of lower water usage rates. For example, TM 5-814-3/AFM 88-11, Vol.3 allows a biochemical oxygen demand (DOD) loading of 0.2 pound per captia per day. At flow rates of 100 gallons per capita per day, that results in a BOD concentration of about 240 milligrams per liter (mg/L). At remote installations in the cold regions the DOD concentration will normally be over 300 mg/L for domestic wastewater, at the typical flow rates ranging from 60 to 80 gallons per capita per day.

c. Temperature. The wastewater temperature at many cold region facilities tends to be at least 50 degrees F due to transmission in insulated and sometimes heated lines. The heat available in this incoming wastewater should be considered during process design.

d. Flow variations. The diurnal flow pattern at military installations tends to be the same regardless of climate and TM 5-814-3/AFM 88-11, Vol.3 must be used to determine peak and minimum flow ratios for design purposes.

9-3. Unit operations.

Practically all of the basic unit operations used in waste water treatment are affected by temperature through liquid viscosity changes or changes in chemical reaction rates. An analysis during the early stages of design is required to predict the thermal status of major components in the treatment system. If wastewater temperatures above 50 degrees F are expected and the entire system is to be housed in a heated building, then conventional practice as defined in the TM 5-814-3/AFM 88-11, Vol. 3 will be used. If temperatures below 50 degrees F are expected, or significant temperature changes are allowed to occur within the system, then adjustments will be necessary in the design of the unit operations. Figure 9-1 will be used to make the necessary adjustments in design to compensate for viscosity effects. The power requirements for mixing, the detention time or size of grit chambers and primary clarifiers and the efficiency of gravity filters will all be adjusted using figure 9-1 where low temperature liquid is expected. For example, a detention time of 2 hours is typiclly specified for primary clarifiers. If wastewater at 35 degrees F is expected, then the detention time will be increased as follows:

$$
\begin{aligned}
\text{Multiplier} &= (3.07)\ e^{-0.0165T} \text{ (from figure 9-1)}\\
\text{At } 35^\circ\text{F} &= (3.07)\ e^{-0.0165(35)}\\
\text{Adjusted time} &= (2\text{ hr})(1.723)\\
&= 3.45\text{ hr.}
\end{aligned}
$$

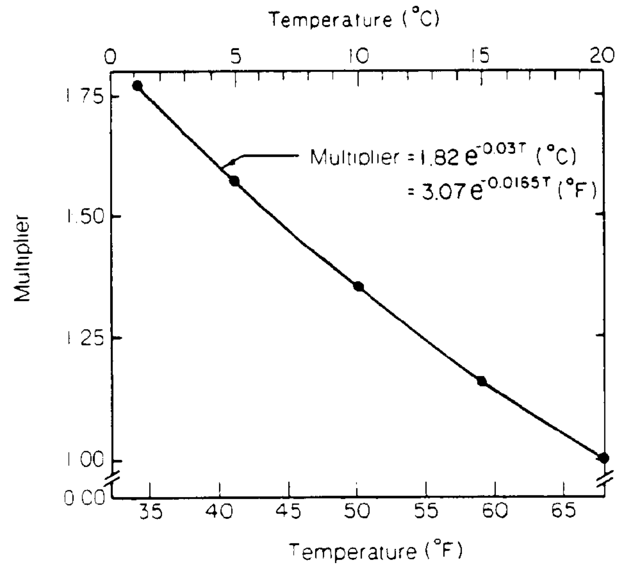

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Figure 9-1. Viscosity effects vs. temperature.

a. Gas transfer. The solubility of oxygen and other gases in water increases as the liquid temperature decreases. However, the viscosity of the liquid also increases so that the opportunity for contact between gas bubbles and liquid molecules is decreased. The net practical effect is little improvement in overall gas transfer in cold wastewater without additional mixing.

b. Adsorption and chemical reactions. Adsorption is not affected by low temperatures, with the range of values experienced in wastewater treatment. Most chemical reaction rates are slower at low temperatures. This can affect treatment and must be considered in preparing chemical solutions for use in wastewater treatment. The solubility of some common treatment chemicals is given in table 9-1.

Table 9-1. Solubility of common treatment chemicals

	Pounds per gallon at	
	32°F	60°F
Alum	6.0	7.3
Ferrous sulfate	0.5	2.0
Sodium hydroxide	2.4	4.4
Calcium hypochlorite	1.8	1.9

c. Flocculent sedimentation. Secondary clarifiers and sludge thickeners generally receive relatively high concentrations of solids and are not dependent on temperature as predicted by Stoke's law. The multipliers shown in figure 9-2 will be used to adjust the size or detention time of these units, depending on the design solids concentration. At solids concentrations of 2000 mg/L or less, and for primary clarification, temperature effects are close to that predicted by figure 9-1, but as the solids concentration increases, the influence of temperature decreases and figure 9-2 will be used. Density currents can completely disrupt the operation of settling tanks and thickeners, so protective ele-

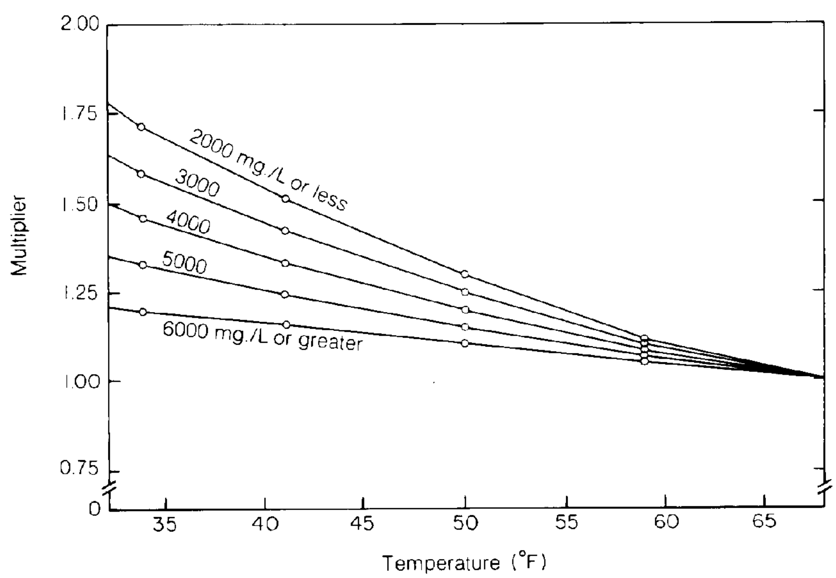

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Figure 9-2. Settling detention time vs. temperature.

ments will be required in cold regions to maintain the temperature of tank contents as closely as possible to that of the incoming liquid.

9-4. Unit processes.

These include preliminary treatment, primary treatment and a variety of biological or chemical processes for secondary treatment. All are subject to temperature influences on their performance.

a. Preliminary treatment. This commonly includes screening, grit and scum removal and grinding or comminution. Conventional equipment can be used and basic design criteria will be in accordance with TM 5-814-3/AFM 88-11, Vol.3; adjustment in grit chamber detention time will be as described in paragraph 9-3 above. Protective, insulated shelters will be constructed over trash racks, bar screens, and grit chambers to avoid icing problems in the winter. Where structures are unheated, condensation and icing may occur on the inner surfaces of exterior walls. In these instances, materials and coatings will be selected accordingly and controls will be located on dry interior walls, or in another remote location.

b. Primary treatment. The design detention time of primary clarifiers will be adjusted, as described in paragraph 9-3 above. In general the tanks will be designed in the conventional manner as buried or partially buried structures. However, the presence of shallow permafrost, particularly ice-rich, fine-textured soils, will require above-ground tanks or special foundations (see TM 5-852-4/AFM 88-19, Chap. 4). Temporary covers for heat retention purposes are recommended for winter operation of buried and exposed tanks in the Arctic and Subarctic. Tanks above grade will also require sidewall insulation or enclosure in a protective structure. Construction details are similar to the procedures described for water tanks in chapter 5.

c. Biological processes. Biological systems for secondary treatment that have been sucessfully used in cold climates include lagoons or ponds, both facultative and aerated, several activated sludge variations, and attached growth systems. Each has special requirements for successful cold regions performance.

(1) *Facultative lagoons.* Where sufficient land area and suitable soil conditions exist, facultative lagoons are the most economical alternative in the cold regions because of their low construction cost and simplicity of operation. Treatment performance during winter is greatly reduced by low temperatures and by ice and snow cover, with removal rates roughly comparable to those of primary treatment alone. Total retention of wastewater during winter months will be required with controlled discharge commencing in late spring and in early fall. This is a common practice in Canada and the north-central United States. Three or more cells will be used to avoid short circuiting. Each cell will be isolated briefly and then discharged in turn during the specified period. Rectangular cells with a minimum 3:1 length to width ratio are recommended to further reduce short circuiting. For a three-cell system, approximately one half of the total volume needed will be provided in the primary cell, with the remainder equally divided among the other cells (a four-cell system will have two-fifths the volume in the first cell). The design BOD_5 loading over on the total area will be 20 pounds per acre per day maximum. The design volume for controlled discharge ponds will be fixed by the time interval between discharges, and not by the minimum detention for BOD_5 reduction. The BOD_5 loading on the first cell in controlled discharge systems will not exceed 50 pounds/acre/day to avoid odor problems.

(a) Design depth. The design depth will be based on winter conditions and will allow a freeboard of 1 foot plus the ice thickness, plus 5 feet from the underside of the ice to the lagoon bottom. Adjustable weirs will be provided at the outlet so that the water level can be raised to provide the necessary depth at the start of winter, and then lowered to the normal operating depth in the summer. Ice thickness will be best determined from actual records or from observations made at small ponds or lakes in the area. An approximation of the maximum ice cover that can occur will be calculated with the following equation, applicable only to unaerated ponds:

$$d = m(I_A)^{1/2} \qquad \text{(eq 9-1)}$$

where

d = maximum ice depth, inches
m = coefficient depending on site conditions
= 0.8 for windy site, no snow cover on ice
= 0.68 for moderate snow cover (see table 12-4 for other conditions), in $(°F•d)^{-1/2}$
I/A = the annual air freezing index, in degree days, °F•d). See TM 5-852-1/AFR 88-19, Vol. 1 for procedure to determine the air freezing index and for typical values.

For example, if Fairbanks, Alaska, has a mean air freezing index of 5500°F•d, and a moderate snow cover on the lagoon is assumed, then the

$$\text{maximum depth of ice} = 0.68\sqrt{5500} = 50.4 \text{ inches.}$$

See section 12, paragraphs 9a and b for additional detail on ice formation.

(b) Special construction features. Standard construction techniques can be used except where permafrost is present. Fine textured, ice-rich permafrost must be avoided if possible, since thawing will result in failure, or at least require frequent repair of dikes and berms. Lagoons may be installed in permafrost that is physically stable after thawing. Construction techniques for dikes and berms, and the use of lining materials are essentially the same as those described in chapter 5. Synthetic rubber has been most commonly used for lagoon liners at military installations in Alaska (see EPA report MCD 54 for additional information). Details of inter-basin transfer structures and outlet works are shown in figure 9-3. The use of the stop-log manhole concept as shown in this figure will permit easy control of depth in the lagoon cells and is an alternative to adjustable weirs.

(2) *Aerated lagoons.* Partially mixed aerated lagoons, also called facultative-aerated ponds, have been used successfully in cold regions. They require less land area, but more energy and more operational attention than facultative lagoons. Basic process design criteria are similar to those of temperate regions. The design is based on:

$$\frac{S_e}{S_o} = \frac{1}{1+kt} \qquad \text{(eq 9-2)}$$

where

S_e = effluent BOD_5, mg/L

S_o = influent BOD_5, mg/L

t = total detention time, days

= V/Q

V = Total volume of lagoon, millions of gallons (mg) or ft^3

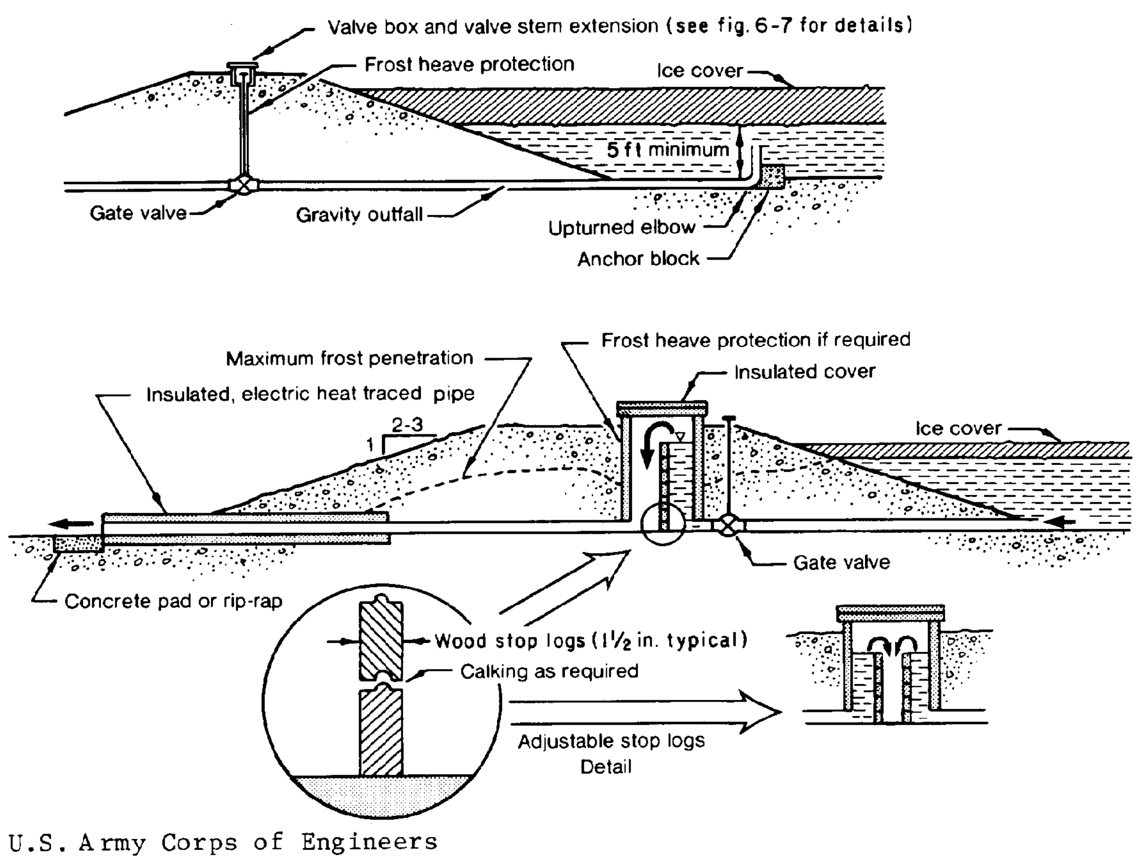


Figure 9-3. Lagoon construction details.

Q = average daily flow, millions of gallons per day (mgd)

k = overall reaction coefficient (base e), $days^{-1}$ as used in Alaska and northwest Canada:
typical winter value = 0.14 ($\approx$ 33°F)
typical summer value = 0.28 (60°F-70°F)
One can also use: $k_T = k_{20}(\theta)^{(T-20)}$
with k_{20} =0.28, θ = 1.036, see table 9-3.

For several cells in series, the equation becomes

$$\frac{S_e}{S_o} = \frac{1}{\left[1 + \frac{kt}{N}\right]^N} \qquad \text{(eq 9-2)}$$

where N = number of cells (other terms are defined above). This equation can be solved to determine the optimum number of cells in the system. In general, winter conditions will determine the number and size of cells and summer conditions will control the design of the aeration equipment. For example, assume the following conditions:

influent BOD = 240 mg/L
efflfuent BOD_5 = 30 mg/L
k_{winter} = 0.14.

Then determine the optimum number of cells using equation 9-3. For one cell:

$$t = \frac{1}{0.14}\left[\left(\frac{240}{30}\right)^{\frac{1}{1}} - 1\right] = 50 \text{ days}$$

and other combinations are shown in the following table.

Number of cells N	Total detention time t, days
1	50
2	26
3	21
4	19
5	18

There is no further significant decrease in total detention time after three cells, so the design should be based on three. The first cell in a three-cell unit should contain about half of the design volume.

(a) Design depth. The effective lagoon depth must allow for ice cover in the winter and sludge accumulation on a year-round basis. Ice will not form continuously over the surface of aerated lagoons. Even under extreme winter conditions (-50°F) there will be small areas of open water where air will bubble to the surface from a submerged aeration system. Aerated lagoons in central Alaska (freezing index >5000°F days) have been successfully designed assuming a 12-inch ice cover. A single-cell lagoon near Anchorage, Alaska (freezing index 2500°F days), receiving warm sewage has an ice cover of less than 3 inches in the winter. If specific values are not available from similar lagoons in a similar climate, an assumed value of 15 percent of the total for design depth is recommended for ice cover allowance in arctic and subarctic regions. About 5 percent will be allowed for sludge accumulation on the bottom. The depth required for treatment in the winter is in addition to both of these factors.

(b) Aeration design. A submerged aeration system is required for year-round operation in arctic and subarctic regions since icing problems can interfere with performance of surface aerators. The aeration design for these partial mix lagoons is based on supplying the required oxygen, not on keeping all of the solids in suspension. As a result, there will be settlement of sludge on the bottom of the lagoon, and some algae growth in the liquid portion. Summer conditions control aeration design since biological reaction rates are the highest and the amounts of oxygen that can be dissolved are the lowest. The oxygen required for partial-mix lagoons will be set at double the organic loading:

$$O_2 = 2(BOD)(Q)(8.34) \qquad \text{(eq 9-4)}$$

where

O_2 = oxygen required, lb/day
BOD = influent BOD_5, mg/L
Q = design flow, mgd.

Under standard conditions, air contains about 0.0175 pounds per cubic foot (pcf) oxygen (specific weight of air at standard temperature and pressure is 0.0750 pcf, with 23.2 percent oxygen), so the air required in cubic feet per minute (cfm) is

$$\text{Air required (cfm)} = \frac{2(BOD)(Q)(8.34)(60)}{(E)(0.0175)(86{,}400\text{ sec/day})}$$

$$= \frac{(0.662)(BOD)(Q)}{E} \qquad \text{(9-5)}$$

where E = efficiency.

The aeration efficiency depends on the depth of water, type of diffuser, mixing turbulence and basin configuration. For example, a typical efficiency (E) of submerged tubing is 16 percent. Therefore, for a design flow of 1 MGD and a BOD_5 of 240 mg/L, the air requirements would be

$$\text{Air required} = \frac{(0.662)(240)(1)}{(0.16)}$$

$$= 993 \text{ cfm}.$$

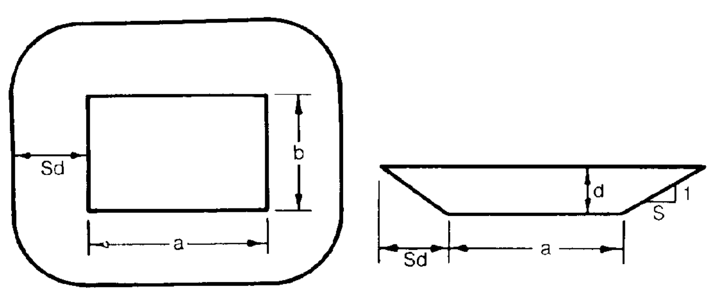
(c) Aeration system operation. Aeration systems that have been successfully used in cold region lagoons include perforated tubing, tubing with diffuser inserts, air guns, and helical diffusers, all available from a number of commercial sources. Table 9-2 summarizes the characteristics of these devices. The values in the table along with equation 9-4 will be used for a preliminary estimate of the number of devices and length of tubing that will be required for a particular system. Manufacturers' literature is then consulted for the final design of a specific system. About 65 percent of the aeration capacity will be located in the first cell of the lagoon system. Submerged tubing and, to a lesser degree, air gun systems are susceptible to clogging due to precipitation of carbonate and bicarbonate salts around the air outlets. The potential severity of the problem increases with the hardness of the sewage. A number of tubing systems in Alaska have been replaced because of this problem. The problem is overcome by including a gas cleaning system using anhydrous hydrogen chloride gas. The acid produced at the air outlets dissolves the incrustations.

(d) Configuration and construction. The prevention of short circuiting and minimization of heat losses must both be considered in design. The optimum configuration for minimal heat loss would be a circular basin with vertical side walls, but construction costs would be prohibitive. A square basin with sloping sidewalls would be slightly more efficient thermally than a rectangular basin of the same volume, but would be prone to greater short circuiting. In general, hydraulics will control design and long rectangular cells (length to width ratio greater than 3:1) will be used to reduce short circuiting. A maximum slope of 1 on 3 is required for interior sidewalls. Figure 9-4 will be used to calculate dimensions of the cells. Inlet and outlet structures, and other construction details, are the same as those described in paragraph 9-4 (1)(6) for facultative lagoons. The general provisions for construction of dikes and lagoon structures will be as required in TM 5-814-3/AFM 88-11, Vol.3.

Table 9-2. Typical aeration equipment.

Equipment	Oxygen Provided* (lb/day)	Common Depth (ft)
Submerged tubing	3-10/100 LF	8-15
Air gun	80-150/unit	12-20
Helical Diffuser	100-400/unit	10-20

*These values can be used to estimate the number of units or linear feet (LF) of tubing required to satisfy the oxygen requirements as defined by equation 9-4. Manufacturers, literature should be consulted for absolute aeration efficiency ratings.



Volume = V = d [(a + Sd) (b + Sd) + .333 S^2 d^2]

Note: The last term (.0472 S^2 d^2) can be dropped for preliminary estimates

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Figure 9-4. Dimensions of lagoons.

(3) *Activated sludge systems.* Systems that have been successfully used in cold regions include conventional and pure-oxygen activated sludge, contact stabilization, and extended aeration concepts, both in package plants and in oxidation ditches. Basic design criteria for these processes can be found in TM 5-814-3/AFM 88-11, Vol.3. When the system is enclosed and incoming waste-water temperatures exceed 50 degrees F, basic design criteria will apply. Special measures are necessary only when incoming wastewaters are below 50 degrees F or if a significant temperature drop is expected within the system. All of the biological reaction rates involved are temperature sensitive, and must be adjusted using:

$$k_T = k\,\theta^{(T-20)} \qquad (9\text{-}5)$$

where

k_T = reaction rate coefficient at temperature T
k_{20} = reaction rate at 20 degrees C
T = design wastewater temperature, degrees C
θ = temperature coeeficient.

The θ values given in table 9-3 will be used in equation 9-5 to adjust the reaction rate for the design wastewater temperature. The basic reaction rate coefficients are found in TM 5-814-3/AFM 88-11, Vol.3.

Table 9-3. Temperature coefficients for biological treatment.

Process	θ	Temperature Range (°F)
Oxidation pond	1.072-1.085	37-95
Facultative lagoon	1.06 -1.18	39-86
Anaerobic lagoon	1.08 -1.10	41-86
Aerated lagoon	1.026-1.058	36-86
Activated sludge	1.00 -1.041	39-113
Extended aeration	1.037	50-86
Trickling filter (conventional)	1.035	50-95
Biofilter (plastic media)	1.018	
Rotating disc		
Direct filter recirculation	1.009	50-86
Final effluent recirculation	1.009	55+
Final effluent recirculation	1.032	40-55

(a) Special requirement. A permanent ice cover must be avoided in the aeration compartments of activated sludge systems. An ice cover will inhibit atmospheric aeration and will entrap solids, both of which reduce treatment efficiency. The design must provide for a minimum of exposed liquid surface area to reduce heat losses. An unheated shelter, a temporary tank cover or a wind break is required during the winter. Clarifiers associated with these systems will require similar protection to avoid freezing and to inhibit density currents. A continuously heated building is not necessary to maintain treatment efficiency. Operator comfort and convenience are the only justifications for such energy inputs. If the incoming sewage is 50 degrees F or warmer there is sufficient heat in the liquid to sustain a protected treatment process. A standby heat source and emergency power are recommended for extended power failures and other emergencies.

(b) Extended aeration. Extended aeration units have been successfully operated with liquid temperatures as low as 33 degrees F and have still produced high quality effluent. Design organic loadings (food/microorganism ratio) of up to 0.08 lb BOD (biochemical oxygen demand)/lb MLSS/day, and mixed liquor suspended solids (MLSS) concentrations of 3000-40000 mg/L are recommended for low temperature operation. Small packaged treatment units must be covered and must be protected from the wind. Pumps, motors, blowers, external pipes, valves and similar appurtenances will require heat as well as a protective shelter. These systems must not be oversized or overdesigned with respect to hydraulic capacity, because low organic loadings usually result in poor performance. Dual units are required for low, intermittent flows at remote installations. Only one unit is operated during low flow periods. This unit is operated with a MLSS concentration. Sludge is then transferred to the second unit during peak flow periods allowing an immediate start-up. Figure 9-5 illustrates the special features of an oxidation ditch in the Subarctic. The aeration basin has vertical sidewalls and a vertical central divider. This reduces exposed surface area and heat losses by about 32% as compared to the conventional ditch with sloping sidewalls and center island. The only heated space in this treatment system is the office/laboratory clarifier equipment and aeration brushes are housed in simple concrete block construction. Condensation and ice forms on the interior surfaces of exterior walls. Thus switches, control panels, etc., must be located on dry interior walls. These features are not unique to oxidation ditches and can usually be incorporated into other systems as well.

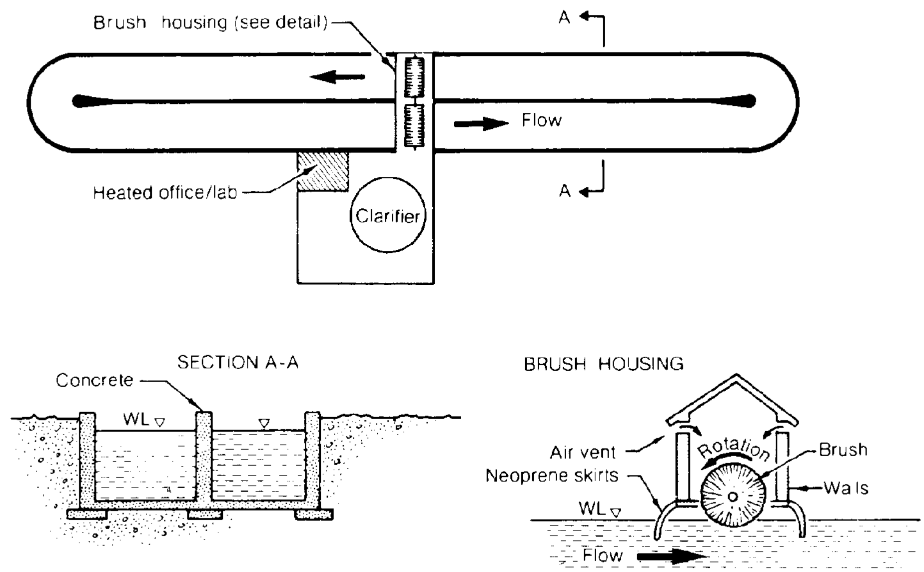

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Figure 9-5. Oxidation ditch for the Subarctic.

(4) *Attached growth systems.* These include trickling filters, rotating biological discs, and other devices with plastic, rock or wooden media. Effective treatment depends on maintaining a thin film of liquid over the media. These units are susceptible to freezing and must therefore be enclosed in a protective structure. Criteria from TM 5-814-3/AFM 88-11, Vol.3, will be used for design, along with the temperature coefficients given in table 9-3. The need for additional heat in the protective structure will depend on the temperature of incoming waste-water and on the degree of treatment required.

9-5. Sludge management.

Large-scale, conventional treatment facilities and those operating in a heated environment can be expected to produce sludge at rates similar to those of conventional temperate zone practice. Typical values for systems in use in the cold regions are presented in table 9-4. Thickening, digestion, and dewatering of sludge all follow temperate zone practice as defined in TM 5-814-3/AFM 88-11, Vol.3.

a. Freeze-thaw dewatering. Sludges from water or waste water treatment operations can be flooded onto conventional open sand drying beds in layers and allowed to freeze. The depth of sludge that can be frozen (or thawed) is calculated with:

$$X = m_s (I_A)^{1/2} \qquad \text{(eq 9-6)}$$

where:

X = depth of sludge that can be frozen, inches

m_s = proportionality coefficient for sludge, use 0.6 for sludge concentrations in range 0-7 percent solids (higher concentrations are difficult to spread on bed), in $(°F{\bullet}d)^{-1/2}$

I_A = Air freezing (or thawing) index, °F•d (use warmest winter of record for freezing calculations)

(1) Sludges with an undrainable jelly-like consistency will dewater immediately upon thawing and then have a granular consistency.

Table 9-4. Typical sludge production rates[a].

Process	Dry solids lb/person/day	Solids content of wet sludge (%)
Primary settling	0.12	6
Trickling filter (TF) Secondary	0.04	4
Primary plus TF Secondary	0.16	5
Conventional activated sludge (AS), secondary clarifier	0.07	0.5-1
Primary plus conventional AS secondary	0.19	2-3
Extended aeration	0.09	2
Lagoons	0.13	20[b]

a Average, 24-hr values, from temperate climate experience.
b High value due to long-term consolidation of sludge on lagoon bottom. Data from partial-mix aerated lagoons in Alaska.

(2) Solids concentrations of 20-25 percent immediately after thawing are typical and after a few more weeks of drying will approach 50 percent. The total depth of sludge that can be frozen is related to the depth of frost penetration that will occur in a particular location. Repeated applications in thin layers is recommended to ensure that each layer freezes completely. The following equation can be used to estimate the potential total depth of sludge that could be frozen (applied in 3-inch layers) if the maximum depth of frost penetration for a site is known:

$$\Sigma X = 1.76\,(f_p) - 40 \qquad \text{(eq 9-7)}$$

where:

ΣX = total depth of sludge that could be frozen in 3 inch layers, in.

F_p = maximum depth of frost penetration for area (see TM-5-852-1/AFR 88-19, Vol. 1), in.

(3) At most facilities it will not be cost-effective to depend entirely on freezing since this would require sludge storage during the warmer months. The optimum design, to avoid storage, will determine the amount of material that can be frozen and then thawed by early summer so that the beds can be used in the conventional drying mode for the balance of the warm season. Polymer additions (in the summer only) will be necessary to condition alum and other metallic hydroxide sludges for conventional dewatering on the sand beds.

b. Sludge disposal. Landfills or land application of sludge are the most appropriate techniques for disposal in cold regions. Temporary sludge storage will be necessary where winter conditions or frozen ground prevent surface application or landfill operations.

9-6. Outfalls.

Outfall structures require special consideration to prevent freezing of the effluent and to prevent structural damage from ice in the receiving waters. In some cases these problems can be avoided by designing for seasonal discharge. However, an unused outfall is still exposed to damage by ice in the winter and during spring thaw. Exposed outfall piping will be insulated and heat-traced. The thermal design will be accordance with section 12. A submerged outfall is recommended wherever possible. However, in shallow streams the pipe must be protected from ice scour that can occur during spring breakup. If possible, the pipe will be installed underground with the outlet completely submerged in water and below the maximum penetration depth of winter ice. If these conditions cannot be satisfied an elevated outfall will be required. Figure 9-6 illustrates a typical elevated outfall detail. The support piling will be designed in accordance with TM 5-852-4/AFM-88-19, Chap. 4, to resist the uplift forces generated by a floating ice sheet. This is particularly critical at coastal locations with significant tidal action. It is usually not practical to design simple pile supports to resist the lateral forces from ice movements during spring breakup. As shown in figure 9-6, break-away couplings will be used to prevent complete destruction of the outfall structure. Elevated outfalls will, in general, be designed to discharge on top of the ice since an open water surface cannot always be maintained. Most of the effluent will then freeze and form a large mound of ice as the winter progresses.

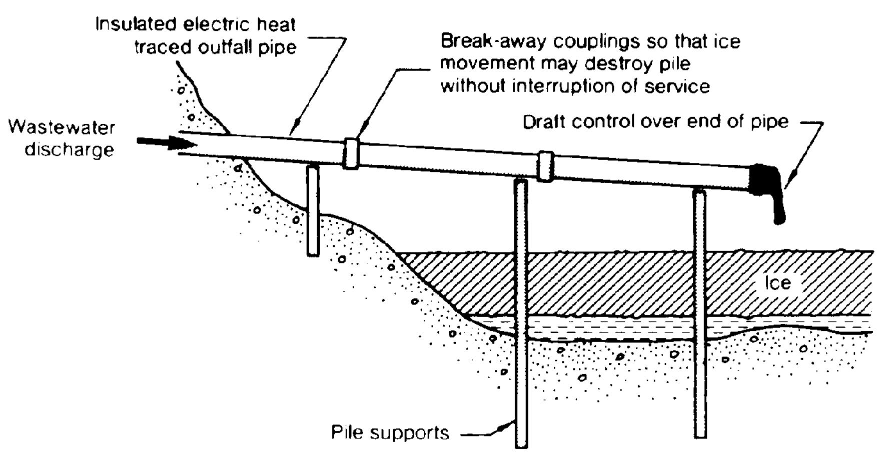

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Figure 9-6. Example of an elevated outfall design.

The pipe must be of sufficient height so that the ice mound does not plug the outlet. A dual outlet constructed as a wye with a valve on each branch has been successfully used to overcome this problem. When the ice mound approaches one outlet, discharge is shifted to the other leg for the remainder of the winter. Figure 9-3 illustrates design details for the buried outfall for a typical cold regions lagoon. A submerged outfall will be similar in concept to the water intake shown in figure 3-3.

9-7. Alternatives to treatment/disposal.

At many remote installations that have small populations or with intermittent usage, it may not be cost effective or technically feasible to construct one of the treatment/disposal options discussed above. Small-scale on-site systems may be feasible for these situations and will be considered. Conventional septic tanks and soil absorption systems have been used throughout Alaska with mixed results. Sludge accumulates at high rates in septic tanks in low temperature soils. Annual sludge removal is required to avoid clogging problems in the adsorption field. Design procedures are similar to conventional practice for these systems. Insulation of the septic tank is desirable; a 2-inch thickness of rigid polystyrene board will retain heat and is recommended for intermittently operated systems. Where feasible, deep seepage pits are preferred over conventional absorption fields because of their greater thermal efficiency. In locations where in--ground disposal is not practical or feasible, vault storage and truck haul will be required. Electric incinerator toilets have been successfully used since 1977 at remote Alaskan stations. These units are not recommended for recreational areas or for transient users. The “grey water” (kitchen, bath and laundry wastes) at these remote stations is discharged to a gravel pad on the ground surface.